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THE MANUFACTURE OF SORGHUM SIRUP.

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U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF CHEMISTRY,
Washington, D. C., January 3, 1899.

SIR: I have the honor to transmit herewith the manuscript prepared by Mr. A. A. Denton, of Medicine Lodge, Kans., on the manufacture of sorghum sirup.

In submitting the manuscript the author says:

In the following pages the simplest means only, suited to sirup makers who have limited facilities, are considered.

A considerable improvement in the quality of sorghum sirup is effected by removing all suspended impurities from the juice. The impurities which neither rise nor settle, and which are not successfully filtered out, injure the product. In this article the matter is considered, being the first and simplest step in the effort to improve the quality of sorghum sirup. The consideration of the second step, the removal of soluble impurities, is reserved for a second article. The removal of these matters is essential to the production of a finished first-class table sirup, and it is intended to work experimentally in that line the coming season, and to test and to develop the most practicable process for removing both the solid and suspended impurities, and also the soluble impurities from sorghum juice, so as to prepare a high-grade table sirup, in place of the crude product which has heretofore been made.

Mr. Denton has devoted many years to the study of the problems connected with the culture of sorghum cane and the manufacture of sirup. Owing to his large practical experience in this work, this article should be of value to the many thousand farmers who annually produce sorghum sirup for their own use and for local and other markets. I therefore recommend that it be published as a Farmers' Bulletin.

Respectfully,

H. W. WILEY,
Chief of Division.

Hon. JAMES WILSON,
Secretary of Agriculture.

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THE MANUFACTURE OF SORGHUM SIRUP.

DEFINITIONS.

The word "sorghum" has a double meaning. It is the name of a cane-producing race of plants, and it is also often used as the name of the sirup which is produced from sorghum canes. To avoid confusion, the words "sorghum plant" and "sorghum sirup" are sometimes used instead of "sorghum." The words "sorghum plant" have also a double meaning. Machinists use the word "plant" as a collective name for the apparatus and machinery required to do certain work. A "steel plant," for instance, is the name for all of the machinery required to produce steel, and a "sorghum plant" would be understood by some to be the apparatus required in manufacturing sorghum, and by others would be understood to refer to the sorghum race of plants.

SORGHUM.

The word "sorghum" is generally understood to include only the sweet, saccharine, sugar-producing varieties of canes. Botanists include in the term, Kafir corn, Jerusalem corn, rice corn, broomcorn, durra, milo maize, and many other so-called nonsaccharine varieties of sorghum. These hybridize, or cross, or mix with each other, and also with the saccharine varieties. They are closely related and belong to the same family of plants. All of the "nonsaccharine" varieties produce more or less sugar, having a content of 2 per cent and more in the juice, merging into the "saccharine" varieties, which contain from 10 to 15 per cent of sugar in the juice. These two classes of sorghum have no distinct line of separation. A variety of sorghum may be said to be nonsaccharine when its juice contains too little sugar for the practical manufacture of sugar or sirup.

When the juice of sorghum canes is clarified in the usual ways, and is concentrated by evaporation until a gallon weighs, approximately, 11½ pounds, the product is known as sorghum sirup or molasses, or as "sorghum." Sugar-cane sirup made in the same way is known in Louisiana as "sirup," the descriptive words "sugar cane" being well understood. It is usually made less heavy than sorghum sirup, and is of less weight than is generally desired by sirup consumers. When reduced to a density of 11½ pounds per gallon, a part of the sugar con-

tained in the sirup is likely to crystallize, and the thin molasses remaining after the partial crystallization of the sugar is liable to ferment. Sugar-cane sirup and sorghum sirup are the concentrated juices of the canes, the easily separated impurities of the juice being removed by more or less imperfect processes of clarification, no sugar being taken from the sirup.

MOLASSES.

Molasses is what remains when more or less of the sugar contained in the sirup has been extracted. In many parts of the country, however, sorghum sirup is called molasses. In Louisiana molasses is classed in two kinds—"O. K.," that is, open-kettle or open-pan molasses, and "centrifugal" molasses. Open-kettle molasses is made in the same way as sugar-cane sirup, but the sirup is boiled in open pan to greater density than is usual in sugar-cane sirup. A part of the sugar in the sirup crystallizes and is removed. The remaining molasses is then reboiled until it is sufficiently thick and heavy. As the excess of sugar has been extracted, the remaining molasses can be concentrated to greater density than is usual in sugar-cane sirup, and the final product is less liable to crystallize or to ferment. As it still contains considerable sugar, this open-kettle molasses is in active demand for use as human food. It is often sold at as high a price or at a higher price than sugar-cane sirup from which no sugar has been taken. In the market reports, sugar-cane sirup and open-kettle molasses are not infrequently quoted before the close of the season with the addition of the words "None in first hands." It is said that the manufacture of sugar-cane sirup and of open-kettle molasses is in many cases as profitable as the manufacture of sugar, and requires less capital and skill; also that the quality of sugar-cane sirup and of open-kettle molasses made in small and cheaply equipped factories is fully equal, and often superior, to that made in costly factories which work on a much larger scale.

CENTRIFUGAL MOLASSES.

Centrifugal molasses is the poorest marketable product of sugar cane. It is what remains when as much sugar as possible has been extracted from the sirup. It is the residue of sugar manufacture. It contains but little sugar, and all of the impurities left in the juice by imperfect clarification. Centrifugal molasses has deteriorated in quality in recent years because of the improved method of extracting the sugar. So much sugar is extracted that the remaining molasses is often so impoverished that it has little value. It is sometimes sold at very low prices, is fed to stock, fermented, or thrown away. It has been proposed to burn it or to return it to the soil. Sugar cane is grown in seven States. In those sections in which but little sugar is made the molasses has a high average value. The yield of molasses

and its value are lowest in the great sugar-producing sections. The reason is that in the former sections the molasses is the principal object of cane manufacture, while in the latter sections the molasses is sacrificed in order to obtain the greatest possible yield of sugar.

In sugar-cane sirup there is often an undesirable excess of sugar. In open-kettle molasses the excess of sugar has been removed. In centrifugal molasses as much sugar has been extracted as is possible.

In each one of these classes there is a wide range in quality and in value. There are as many as ten commercial grades, namely, "Fancy," "Choice," "Strict prime," "Good prime," "Prime," "Good fair," "Fair," "Good common," "Common," and "Inferior." At this writing sugar-cane sirup, in its home wholesale market, New Orleans, brings 26 to 28 cents a gallon; open-kettle molasses, 21 to 32 cents, and the medium grade, "Good fair," 25 cents a gallon. Centrifugal molasses now brings from 8 to 20 cents, and the medium grade, "Good fair," 12 to 13 cents a gallon. In Northern wholesale markets sorghum sirup of average quality brings less than sugar-cane sirup, less than open-kettle sugar cane molasses, and ranks in the great trade centers about the same as the middle grades of centrifugal molasses.

SORGHUM SIRUP AND SUGAR-CANE SIRUP COMPARED.

The manufacture of sugar-cane sirup and molasses is worthy of careful study by sorghum-sirup makers. It is said that in the manufacture of sugar from sugar cane or sugar beets from one-half to three-quarters of the expense is in procuring the cane or the beets. Sorghum cane is produced more cheaply than either, having 13 or 14 pounds of sugar in 100 pounds of the juice. When such cane is properly utilized it should be worth $2 a ton to the cane grower and $4 a ton to the manufacturer, giving a profit to both. It is possible to clarify sorghum juice of average quality so as to remove the impurities which give the sirup its undesirable qualities, and to secure a product which is as acceptable as sugar-cane sirup or molasses.

When the impurities in sorghum juice, which give the sirup its undesirable qualities and which also hinder crystallization, are removed, the sirup is improved in quality, and also crystallizes readily. When first-class sirup is made from sorghum it is necessary to extract the excess of sugar from it and make open-kettle molasses, as is done with sugar-cane sirup. This is necessary to make the excess of sugar in the sirup uncrystallizable, as is sometimes done in the manufacture of sugar-refinery sirups. In an attempt to improve the quality of sorghum sirup by using superior means for clarifying the juice, the writer made 6,000 gallons of sirup, which had 6 pounds of sugar in each gallon and which yielded 4 pounds of unrefined sugar of good quality from each gallon. But such sirup when reduced to the density required for sorghum sirup becomes "mush sugar," which

is a mixture of sugar and molasses. It can not be relied on to remain sirup. In this case, after the excess of sugar had been extracted, the remaining molasses was reboiled to thick molasses, which was open-kettle sorghum molasses. It was sold at the same price that the sirup was worth before the extraction of the sugar.

LITTLE CHANGE IN PROCESSES OF MAKING SIRUP.

The manufacture of sugar-cane sirup and of sorghum sirup has changed little in the past forty years. The processes now used are essentially the same as they were then. A little lime, heat, a partial separation of impurities from the juice by skimming or settling, or both, and evaporation by open pan are the means generally employed. This lack of progress is in striking contrast with the improvements which have been made in nearly all other manufacturing processes during the past forty years. Improvement in sugar-cane sirup manufacture is much less necessary than it is in the manufacture of sorghum sirup, because sugar-cane juice is naturally much purer than sorghum juice. When 100 pounds of Louisiana sugar-cane juice are evaporated to dryness, about 90 per cent of the dry solids which were in solution in the juice consist of cane sugar and glucose and about 10 per cent of the dry residues consist of substances which are neither cane sugar nor glucose. In the dry residues of sorghum juice, about 75 to 77 per cent consist of cane sugar and glucose, and nearly one-fourth of the solids which were in solution consists of substances which are neither cane sugar nor glucose. Sorghum juice contains fully twice as much impurity as sugar-cane juice. It is this excess of vegetable impurities which places sorghum-sirup manufacture at a disadvantage. When the excess of impurity is removed, the disparity between sugar-cane sirup and sorghum sirup ceases. Sorghum-sirup manufacture has declined, and must continue to decline, unless purer juice can be obtained from better varieties of sorghum, or unless the juice can be made purer by better clarification.

The fact that the quality of sorghum sirup or of sugar-cane sirup has not improved in the past forty years is not good cause for abandoning attempts to improve the manufacture of either. It was sixty-five years after Margraff began the manufacture of beet sugar that Barruel discovered the carbonatation process of purifying beet juice which is now successfully used in making 5,000,000 tons of beet sugar annually. It was sixty-four years after the Russian chemist Kirchoff began glucose manufacture that American glucose manufacturers found the right way out of their difficulties, enabling them to produce at the present time 1,000 tons a day of liquid corn sirup and solid starch sugar. It is now only necessary to find the way to purify sorghum juice properly in order to quickly develop an extensive and profitable manufacture of sorghum sirup. It is not necessary that a great invention or discovery should be made. Some of the methods of clarifying saccharine liquids which have been developed and successfully used by beet-sugar makers,

cane sugar makers, sugar refiners, or by glucose makers may be found to be also adapted to the clarification of sorghum juice. These pages are written with the purpose of stating the facts and the difficulties of sorghum-sirup manufacture in a general way, with a hope of inducing sirup makers to improve their processes rather than with the intention of assuming to state the precise methods to be used.

STATISTICS OF SORGHUM PRODUCTION.

The improvement of sorghum-sirup manufacture is not a small matter, nor is it a matter of merely local importance. The production of sorghum sirup was, in 1860, 6,749,123 gallons; in 1870, 16,050,089 gallons; in 1880, 28,444,202 gallons; and in 1890, 24,235,218 gallons.

In 1889, 11 States produced over a million gallons of sorghum sirup each. It was produced in greater or less quantities in 44 States and Territories. Missouri, Tennessee, Kentucky, Arkansas, Texas, Kansas, Iowa, Georgia, North Carolina, Alabama, and Illinois, in the order given, produced the largest quantities, ranging from 2,721,240 gallons in Missouri to 1,110,183 gallons in Illinois. The report of the Kansas State Board of Agriculture shows that in 1890 that State produced 3,431,100 gallons of sorghum sirup, not 1,484,937 gallons, as stated in the national census returns, thus placing Kansas easily first instead of fifth in sorghum-sirup production.

These statistics show the adaptation of sorghum to a wide range of conditions of soil and climate, scarcely second to that of corn. Sorghum succeeds in semiarid sections where corn often fails. Its cultivation extends far to the north, 3,890 acres being grown in Minnesota, and to the south, 1,755 acres being grown in Louisiana for sirup production. Its acreage is greatest in the States of the plains, Kansas having in 1898 nearly a million acres of all varieties, saccharine and nonsaccharine.

The census of 1890 shows that sorghum-sirup production had declined as compared with the census of 1880 in thirteen States and had increased in eight States. Generally the production had declined in 1890 about 15 per cent from that in 1880. It is believed it has declined still further since 1890. The conditions of sorghum-sirup manufacture in 1899 disappoint the hopes that were cherished in the years 1850 to 1880. In order to bring prosperity to this declining industry, it is necessary to improve the method of manufacture so as to produce a first-class finished table sirup, which will be in demand by all classes of people, instead of the crude, acid, turbid, rank-flavored, and dark-colored sorghum which is often made by the primitive processes now used.

SORGHUM IN SEMIARID SECTIONS.

In recent years the acreage of sorghum has immensely increased in the semiarid sections of the West. The ability of sorghum to endure

drought is a very valuable quality of the plant, for it enables it to live where other plants often perish. Sorghum was brought to this country from the arid sections of Asia and Africa, and it has the ability which is found in plants in arid sections to suspend growth when moisture is lacking and to renew growth when rains come. But the sorghum-sirup manufacturer in semiarid sections has more need for efficient means for removing impurities from the juice than those in more uniform climates. The canes are at times wilted and drooping, the juice containing from one-fifth to one-fourth of its weight of solid matter. Impurities often do not settle well from such dense juice. When rains come the canes renew their growth. The juice is then loaded with vegetative matter, which often neither rises well as scum nor settles well as sediment. Intermittent growth of the canes caused by drought and flood often impairs the quality of the sirup which is produced in the semiarid sections. As a rule, the sirup produced in such localities is inferior in quality to that produced in more regular climates, where the canes are subjected to fewer droughts and floods. All sorghum-sirup makers need more efficient means for purifying the juice. The sirup makers in the semiarid sections, in which the largest acreage is grown, have especial need for better separation of the excessive amount of vegetative impurities which their sorghum juice often contains.

There seem to be two ways in which the quality of sorghum sirup may be improved. The first is the selection of varieties of sorghum which yield purer juice, or which yield impurities which are less objectionable or which may be more easily removed from the juice. The second way is the use of more efficient processes for purifying the juice or the sirup.

IMPROVED VARIETIES OF SORGHUM.

There are many hundreds of varieties of sorghum. They differ in external qualities, such as size, height, yield of seed, color of seed top, time of maturing, etc. They also differ in quality of juice, such as the amount of sugar contained and the percentage of glucose, and they probably also differ in the nature, kind, or quantity of impurities contained in the juice. In the numerous varieties of sorghum which are known there are surely a few which are preeminently adapted to sirup manufacture. There are many varieties of the maple tree—one, the rock maple, is esteemed as the best for maple-sirup manufacture. There are many varieties of the palm tree—one, the sugar palm, is considered the best for sirup or sugar manufacture. The "Creole" cane in Louisiana is considered the best for some uses, and some other varieties the best for sugar manufacture. It seems evident that all varieties of sorghum are not exactly alike in any respect, and that a few are certainly superior for sirup manufacture. There are many kinds of sorghum which have never been tested properly, in a strictly comparative way, in sirup manufacture. Gardeners, grain and fruit growers,

and florists know that the planting of certain varieties is essential to success and there is a general agreement among them in regard to the best ones. There is no such general agreement among sorghum-sirup makers in regard to the best kinds for their purposes, except that early-maturing canes, the Early Amber for instance, are best in sections where the growing seasons are short. The writer obtained 200 samples of sorghum sirup from twenty States, with statements in regard to the varieties preferred, soils, and methods of manufacture used. No satisfactory conclusions could be formed from these samples or statements.

When varieties have been chosen for sugar or for sirup manufacture, for grain or seed production, for forage or for broom making, they may be much improved by the selection of seed from the best plants. Sorghum responds quickly to efforts made to improve it by the selection of seed. It was imported from countries in which selections for quality of juice had not been made. In an undeveloped plant or race of animals the first improvement caused by selection is often rapid, and the last improvement is slow, as it nears the limit of improvement. When a plant is transferred to another country, as was the case with sorghum, it often varies to meet the new conditions, and thus new, often superior, varieties are produced. This is true of the apple, the grape, the chrysanthemum, and many other plants. The best of these for this country are American varieties which sprung from those which were imported. These are sometimes superior on American soil to those from which they sprung on their native soil. The same will doubtless be true of sorghum when selections have been made, as has been done with other plants.

EXPERIMENTS BY THE DEPARTMENT OF AGRICULTURE.

In the years 1888–1893 the Department of Agriculture experimented in the improvement of sorghum cane for sugar manufacture by the selection of varieties and seed from single canes of superior quality. In reviewing the results Dr. H. W. Wiley, Chemist of the Department, said: "The data indicate most clearly a gradual, in some cases a rapid, improvement in a larger quantity of sucrose, a smaller quantity of glucose, and in a higher purity."

EXPERIMENTS BY THE KANSAS STATE EXPERIMENT STATION.

The Kansas State Experiment Station also attempted the improvement of sorghum cane for sugar manufacture by the selection of seed. The results are stated as follows:

> The work in seed selection has been in progress five years and has been attended with a constant improvement in the quality of sorghum. Indeed, it seems that the plant may be modified in almost any desired direction.

VARIETIES OF SORGHUM SELECTED FOR SUGAR MANUFACTURE.

In five years of experimenting in improving varieties of sorghum for sugar manufacture five were selected which contained much more sugar in the juice than the common canes. Sorghum has been and may be improved for sugar manufacture. It may also be improved for sirup manufacture. The varieties selected for sugar manufacture were:

The *Collier*, imported from South Africa. It is the best or one of

FIG. 1.—Seed heads of the Collier variety of sorghum.

the best varieties for sugar manufacture, having a very high percentage of sugar and a low percentage of glucose or uncrystallizable sugar in the juice. It does not yield seed abundantly, nor are the canes large, averaging about a pound in weight. Though slender,

canes of this variety are believed to be tangled, broken, or prostrated by wind storms less often than other canes. There are some who believe it to be one of the best varieties for forage.

The *Amber-Orange* originated in a cross between Early Amber and Kansas Orange. This cane was tested for five years by the Kansas State Experiment Station, and was considered one of the best for sugar manufacture. It does not produce seed abundantly.

The *Colman*, also a cross between Early Amber and Kansas Orange, is generally preferred because it produces canes of good size, not tall, with juice of good quality, and also produces seed abundantly.

Variety 161 originated in a cross between Early Amber and Link's Hybrid. The canes are tall and slender, which is a fault derived from Link's Hybrid. It ripens rather early, much earlier than Link's Hybrid. Its juice remains good, ordinarily, long after the canes are ripe, though standing uncut in the field. The juice has, on an average, as large content of sugar as the average juice of Louisiana sugar cane, and much less glucose or uncrystallizable sugar.

Folger's Early is also a cross between Early Amber and Link's Hybrid. It ripens not long after Early Amber and remains good, standing uncut in the field, much longer than Early Amber. It yields more cane and more seed per acre than Early Amber. It is considered the best early-maturing variety for general planting.

FIG. 2.—Seed head of Amber-Orange sorghum.

The *Early Amber* variety, a quick-maturing cane, is liked better in the North than in the South. It is the best variety for early ripe cane or for late planting, and for sections in which the growing season is very short.

NEED OF SYSTEMATIC SELECTION OF VARIETIES OF SORGHUM SUITABLE FOR SIRUP MANUFACTURE.

It is believed that in five years of similar tests of all obtainable varieties of sorghum, and of many crosses and variations, five varieties could be selected and developed which would be as much superior for sirup manufacture as are the above-named for sugar manufacture.

Those who grow cane mainly for the seed or grain have very generally selected Kafir corn, a nonsaccharine variety of sorghum, as being the best for their purpose. The Dwarf and the Standard varieties of

broom corn, also nonsaccharine varieties of sorghum, have been selected by manufacturers of brooms, as being decidedly superior to all others for their purpose. Those who grow sorghum for forage, for "stover," or "roughness," and also those who grow sorghum for sirup manufacture have not yet learned which kinds of sorghum are superior for their purposes. Selections for sirup manufacture should be made by testing on a small scale, in a strictly comparative way in the laboratory, all obtainable varieties, and by again testing in a practical way those which seem best. Such experimental work would doubtless benefit

FIG. 3.—Seed heads of the Colman variety of sorghum.

those who produce the twenty million or more gallons of sorghum sirup now produced annually in this country, and would also benefit those who consume the sirup.

At the present time, it is impossible to say which varieties of sorghum are best for planting for sirup manufacture. Those which have been selected as best for sugar manufacture are not, perhaps, best for producing sirup. The McLean variety, for instance, is, by chemical analysis of the juice, one of the best for sugar manufacture, but its

juice has often if not always an unpleasant flavor, and the sirup is of poor quality. Varieties which are best for sugar making are quite likely to give sirup which crystallizes or grains readily. This is desired by sugar makers but not by sirup makers.

PREPARING THE SOIL, PLANTING, AND CULTIVATION.

Sorghum is so extensively grown over a wide area, and in such different conditions of soil and climate, that quite a variety of methods of growing the canes are employed. In the semiarid sections of the

FIG. 4.—Seed heads of Folger's Early variety of sorghum.

West, where most of the sorghum is grown, the greater part is "listed." A double-moldboard plow with a planting attachment is used to make furrows the proper distance apart for the cane rows, throwing up ridges between the furrows and planting the seed at or near the bottom of the furrows, considerably below the level of the field. In some sections of the South cane is planted upon ridges, above the level of the field, in order to secure drainage. In other sections the land is plowed, harrowed, and the seeds planted at the level of the surface. Those who "list" believe that method is, for them, the cheapest way to prepare

the soil and plant the seed; and that it is easier to cultivate the crop, the soil being worked down to the canes by the cultivations, so that when the crop is "laid by" the canes are on the level or are but slightly hilled. They also believe that this method utilizes scanty rainfall better, the water flowing to the canes instead of away from them, as happens when the canes are hilled. It is more difficult to keep the rows of cane free from weeds when planted above the level of the soil. Planting the seeds at the level of the field is safer than listing, because sorghum is small and grows very slowly in its first weeks, and when the seeds are placed below the level the plants are liable to be covered by sand or dust storms, or by flooding rains. Sorghum should be planted and cultivated as is best for corn in any given locality. More care is needed in the first cultivation to work close to the rows and to avoid injuring the "stand" by covering the plants, than is considered necessary for corn.

The rows of cane are usually 3 feet 6 inches or 3 feet 8 inches apart, and, in order to give room for full development of the canes, the plants should be not less, generally, than 4 inches apart. There are few who "check row" sorghum and cultivate in two directions crosswise. There are some who prefer to have the rows 4 feet apart and to have the canes 6 inches apart in the rows. In the West, thinning the plants to a proper stand is seldom done. Usually, thinning is insufficiently done and the canes are too close together for the best development. Such canes suffer more from drought than when rightly planted. It is believed that nothing is gained by very early planting, and that it is better not to plant until the soil is warm and the weeds have started. In the West, two or three cultivations are usually given. Cane seed is often imperfectly cleaned for planting. No planting machine is known which plants trashy sorghum seed correctly and regularly. The fibrous stems and imperfectly thrashed seeds remain in the seed box and hinder proper dropping of the seeds. It is better to "pan" the seeds when planting, as gold diggers in placer mining "pan" earth and sand. By giving the pan a shaking or whirling motion the clean cane seed settles to the bottom and the trash is then readily removed by hand from the surface. When sorghum seed is of mixed varieties which ripen at different times, the canes produced are often unripe, ripe, and overripe in the same row. After the canes have been harvested, examination of the stubble often shows that if there had been fewer vacant spaces in the rows, fewer places where the canes were too far apart or too close together—that is, if more care had been taken in the planting and in the cultivation—a much larger yield of cane of better quality for sirup manufacture could have been had with no additional expense. When the cultivation is done at the right times it is often much more effective and more easily done than when done at other times. It is not as easy to plant sorghum so as to get a good stand or to do the first cultivation well, cleaning the rows, without injuring the stand, as in growing corn.

GRINDING CANE.

Tropical sugar cane is usually harder to grind than Louisiana sugar cane. The latter, though much larger and harder than sorghum cane, gives better extraction of juice. A ton of average sorghum cane may be made to yield 20 gallons of sirup. It usually yields from 10 to 12 gallons. Where cane is cheap and abundant it is often considered inadvisable to greatly increase the extraction of juice by excessive pressure of the canes. Juice obtained by moderate pressing is purer than that obtained by extreme pressure, for this extracts not only more juice, but also more impurity from the shell and the joints of the canes. With limited power, a larger quantity of sirup can be made in a given time from moderately pressed cane than from a less quantity of cane subjected to greater pressure. But there is generally much unnecessary waste of juice in grinding sorghum cane. The rolls often need to be "turned"—that is, reduced to even diameter, the bearings need babbiting, and the rolls need to be properly adjusted to each other. The "feed"— that is, the amount of cane in the mill at one time—should be light or heavy according to the adjustment of the rolls. When the rolls are set "open" the feed should be heavy; when they are set close together the feed should be thin, or light; but in both cases the feed should be regular and uniform. It is evident that when the rolls are set "open", or apart, there is waste of juice when the feed is light, and also that canes can be well pressed though the rolls are not set close provided the feed is heavy.

HORSEPOWER MILLS.

When a horsepower cane mill is set up higher above the ground than is necessary, a part of the power of the horse is uselessly expended in twisting the "sweep" or lever. If it be set too low, it is inconvenient for work. The cap—that is, the casting to which the sweep is attached—should be about 60 inches above the ground. The hitching point of the sweep should not be much above or below that used when attaching a horse to farm implements. A double sweep—that is, two levers opposite each other, having an evener or equalizer of rope, wire, or chain, passing over the double sweep—is better than a single sweep, having two horses working together. It is better to have the circle or path traveled by the horse of not less diameter than 25 feet. A horizontal lever or sweep, such as is used in miners' hoists or "whims," seems much better than a curved sweep, the lever being less in the way of the work. The horse works under the sweep and is attached high up, only a few links of chain being used for traces, hence there is less loss of power. But such attachment is more expensive in first cost. A stiff sweep is said to do better work than one that is flexible. A first-class mill, well adjusted and properly fed with cane, is usually

cheaper and more effective in the long run than a cheap mill which is carelessly operated.

It is said that, for horsepower, vertical mills which permit the sweep to be directly attached to the shaft of the main roller, cost less, require less power, last longer, and get as good extraction of juice as mills having horizontal rolls. A four-horse mill is as large as is profitable for horsepower. Larger mills should be operated by steam or water power. The separate horsepower cane mill seems to require a large excess of power. Two horses, or even one horse, can be used on a four-horse mill when desired. It is convenient to use a four-horse mill, grinding cane and settling the juice in the forenoon, evaporating the settled juice to sirup in the afternoon—not grinding cane then—giving ample time for well settling the juice, and making night work unnecessary. As much sirup can be produced in this way with the same help as can be produced with a small mill which grinds cane all day, finishes often in the night, and gives too little time for proper clarification of the juice.

CLARIFYING THE JUICE.

In modern manufactures there is a marked tendency to the use of complex processes instead of the few and the simple processes which were formerly used. The manufacture of flour, for instance, was for thousands of years a very simple matter. Now a flouring mill is a factory filled with machines, each performing a part and having a purpose unthought of in old times. In the manufacture of sugar-refinery sirups, and of glucose, and in purifying beet juice for sugar manufacture, as many as ten clarifying processes are often used. In the manufacture of sugar from sugar cane, although that is a comparatively simple matter, the juice is purified in more ways than it is in the manufacture of sirup. Sugar-cane juice is filtered once, sometimes twice; beet juice is generally filtered twice, sometimes three or even four times. Sugar makers and refiners use all known effective processes in clarifying their liquids, yet they have not so impure a liquid to deal with as sorghum-sirup makers. Their products are superior and their manufacture is successful, because they employ many processes instead of the simple processes which are used in sorghum-sirup manufacture. The question is often asked, What can I put into sorghum juice so as to make good sirup? No single process is known which will remove all undesirable substances from sorghum juice at one operation. It is said that as many as fifty substances have been identified in beet juice. Probably sorghum juice is as complex. It contains a larger percentage of vegetable impurities than beet juice.

It contains several classes or kinds of impurities. Clarification of the juice is a process of subtraction, removing the various classes of impurities by different methods. The use of lime, neutralizing natural acids contained in the juice, helps to remove some of the impurities,

while heat coagulates others. Some of them are lighter than the juice and rise to the surface, and may be removed by skimming. Other impurities are heavier than the juice and settle, and may be removed by drawing off or decanting the clarified juice, leaving the sediment. Some neither rise nor settle, and can be removed only by adding albuminous substances, such as milk, blood, white of egg, etc. These coagulate in the liquid and rise to the surface, bringing up the impurities which were suspended in the juice, and which may then be removed by skimming. Suspended impurities may also be removed by weighting them with clay, or other suitable substances, which causes them to settle, after which the clarified juice can be removed by decantation. The suspended impurities may also be removed by filtering, the filtering material allowing the juice to pass through, but restraining the solid matters contained in it. When all of the solid impurities contained in sorghum juice are removed by skimming, by settling, or by filtering, there remains a class of impurities in solution, and which can not be removed by mechanical means only. When those which are in solid form and those which are in solution are well removed, the sirup which is produced is fully equal to any cane sirup in the market. Improvement in the quality of sorghum sirup is to be looked for in the use of efficient processes for removing the solid impurities, and, also, the impurities in solution in the juice, thus producing a finished first-class table sirup.

THE USE OF LIME.

Nothing has been found better than lime for neutralizing the acids contained in sorghum juice. It is used by all cane-sugar and beet-sugar makers and sugar refiners as a necessary means for clarifying their liquids. The use of lime in sorghum juice is, in some respects, quite unsatisfactory. The juice is always acid, sometimes strongly acid. Sirups containing all of the acids naturally in sorghum juice, concentrated by evaporation, from 6 to 8 gallons of juice to 1 gallon of sirup, are too acid to suit the great majority of sirup users, who are accustomed to the mild, neutral sirups made by refiners and mixers. The acids also hold impurities of the juice in solution, so that these can not be removed. Proof of this is seen when sorghum juice is limed until neutral—that is, neither acid nor alkaline. A part of the impurities then becomes solid. By adding acid to the juice these solid impurities redissolve and go into solution in the juice again. But lime not only neutralizes the acids; it also attacks and degrades other substances in the juice. A large quantity of lime is used in beet juice without harm. A larger quantity can be used in sugar-cane juice with less harm than can be used in sorghum juice. When a sample of sorghum juice is limed to excess on a cool morning it is seen that the juice is not discolored when the temperature is below 59° F. It becomes slowly discolored when the temperature rises above 60°. It is rapidly discolored above 80°, and is instantly discolored at

the boiling point. This seems to indicate that it is better to lime the juice when cold. Lime changes by keeping, losing strength by absorbing carbonic-acid gas from the air and forming more or less carbonate of lime. Lime is but slightly soluble in water. Seven hundred pounds of water dissolve 1 pound of lime, and it does not long remain in suspension in water, so that the phrases "milk of lime" or "cream of lime" convey an indefinite idea of the amount of lime contained in the liquid. Common lime is also often made from very impure limestone. As has already been said, sorghum juice varies greatly in degree of acidity, sometimes requiring much more lime than at other times. For these reasons it is not possible to form a general rule for liming sorghum juice, except that after the process the juice should always slightly redden a strip of blue litmus paper which has been immersed in the limed juice. This indicates that the juice is still slightly acid and that too much lime has not been used. It is unsatisfactory to use too little lime, difficult to use the proper quantity, and the sirup is injured when too much is used. When too little lime is used, the clarification is imperfect, the juice is gummy and can not be filtered, and the sirup has a more or less rank flavor. When lime is rightly used, a larger amount of impurity can be removed by skimming and settling and the sirup has a pleasanter flavor and keeps better. The proper liming of sorghum juice is so difficult that most sirup makers do not practice it. The few who do take care to employ too little lime. This practical difficulty in properly neutralizing the acids in sorghum juice has long stood in the way of progress in sirup manufacture. The use of lime or of an equivalent substance appears essential to the production of an improved quality of sirup. Glucose makers have a saccharine liquid containing dilute acid which it is necessary to neutralize. They can not use lime, because quicklime injures their liquid, as it also injures sorghum juice. They remove all traces of the acid by adding, at intervals of ten or fifteen minutes, powdered carbonate of lime, limestone, marble, or chalk, in small quantities, stirring the liquid slowly and continuously for a considerable time. If its action should be the same in sorghum juice as it is in glucose liquor, there would be very great advantages in using carbonate of lime instead of free lime. It is cheap, used in excess it is not harmful, and it does not give sirup the flavor which limed sorghum sirup has. It does not change by keeping, and the acids could, practically, be more perfectly neutralized than can be done by caustic lime. Until further experimental work has been done, sorghum-sirup makers should use lime sparingly, about a pint of milk of lime (not cream of lime), like whitewash, in 50 gallons of juice. The limed juice, after thorough mixing, should slightly redden a piece of litmus paper.* It seems preferable to lime the juice before heating.

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*Red and blue litmus paper can generally be purchased at drug stores. Alkaline liquids, as lime water, turn red litmus blue; acid liquids, as vinegar, turn blue litmus red.

SKIMMING, SETTLING, AND FILTERING.

As a rule, sorghum-sirup makers are careful to remove by skimming the impurities which rise when the juice is heated, but are not careful to remove by settling the heavier impurities, and they never remove by filtration those which neither rise nor settle, but remain suspended in the juice. Cane-sugar makers, beet-sugar makers, glucose makers, and sugar refiners, brewers, cider and wine makers, all pay much more attention to settling and filtering. Sugar makers and refiners have reason to hurry their processes, since sugar becomes more or less uncrystallizable by long standing; but they nevertheless take time enough to settle and to filter their liquids well. Inversion is not detrimental in sorghum-sirup manufacture, since it hinders the sirup from crystallizing. There is a very general impression among sorghum-sirup makers that it is necessary to "rush the juice." The reverse is true before heating begins and until fermentation threatens. There seem to be advantages in settling the cold juice and removing starch grains, slime, and suspended matters at first instead of cooking them in the juice. There are some impurities in sorghum juice which are insoluble in cold, but become soluble in hot juice. Starch is one of these impurities, and it is believed that the soluble starch formed when starch is heated in the juice gives a peculiar flavor to sorghum sirup. Sorghum juice often does not settle well, either when cold or hot. The impurities which the sirup maker leaves in the sirup go to the table of the consumer. It seems apparent that the way to improve the quality of sorghum sirup is to treat the juice so as to cause the impurities to become insoluble, and permit easy filtration or good settling. Then skim off the lighter impurities, settle out the heavier ones, and remove those which neither rise nor settle by weighting them, so as to cause them to settle, or by adding some substance which coagulates and causes them to rise, or by filtering the juice. At present the sirup makers generally have only the simplest appliances. They can use only the simplest processes, and only those processes of clarification will be discussed here.

The most efficient means for clarifying saccharine liquids known consists in adding to the cold juice some liquid substance which coagulates or becomes solid by heating, and then heating the mixture. The particles of solid substances which are thus formed attract and adhere to the suspended matters, and both the added substance and the suspended matters may then be removed; or in adding two substances which combine in the liquid and form a solid compound, the particles of which also attract and adhere to the solid impurities, so that both may be removed by settling or filtering. Beet-sugar makers all add lime, then inject carbonic-acid gas into the juice, forming solid carbonate of lime, which is insoluble and which greatly assists in the removal of the impurities. The addition of lime and of

carbonic-acid gas is made twice, sometimes three times, to beet juice. At present this method of clarification, which is so successful in clarifying beet juice, is not practicable in sorghum-sirup manufacture. Cane-sugar makers and sugar refiners often add lime and superphosphate of lime to their liquids, forming solid phosphate of lime in the juice, which attracts and adheres to the solid impurities of the liquid, so that both may be removed. Much work has been done on this process in sorghum manufacture. It greatly increases the purity of the juice, but it requires care. If too much lime be used, the sirup is injured. If too much superphosphate of lime or acid phosphate of calcium, as it is sometimes called, be used, the impurities of the juice redissolve, the liquid is cloudy, and the sirup is too acid.

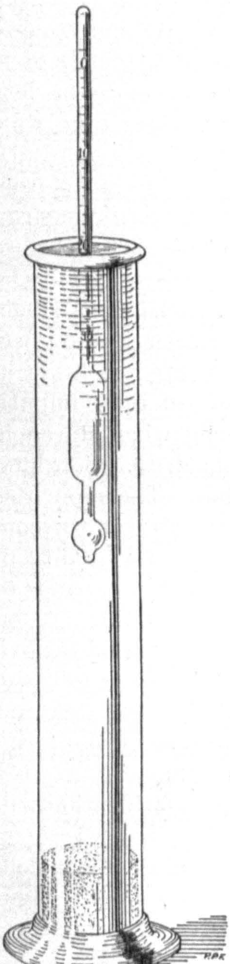

FIG. 5.—Jar and spindle used for determining the density of sorghum juice and sirup.

CLAYING THE JUICE.

The simplest practicable way of partially clarifying sorghum juice known to the writer consists in adding clay to it in order to weight and carry down the suspended impurities which do not rise as scum, and which settle slowly or not at all. This process is not new, having been used many years ago in sugar cane and in sorghum manufacture. It is an imperfect process, but when properly applied it gives better sirup than merely boiling and skimming the juice. In an extreme case, sorghum cane taken from a pile in April gave impure, strongly acid juice, the density of which was 18° Brix. When limed, the density was 18.5° Brix. After clay had been added and well mixed with the juice, the density was 21° Brix, and after settling the density was 15° Brix. Without the aid of heat the process had removed one-sixth of the total solids of the juice. This process requires the use of a suitable clay, sufficient time for settling, and proper care in keeping the settling tanks clean, sweet, and free from fermentation. The use of lime, when not in excess, is an advantage, but is not essential. It promotes the separation of the impurities of the juice and also facilitates the settling of the clay by causing the particles to "flocculate;" that is, to adhere together and form compound grains which settle more readily. Usually a fair quality of clay can be found by testing clays from different localities. It often

varies much, in respect to the fineness of the grains, within a small range. Some clays have particles so small that they settle very slowly, leaving water cloudy for days. Such clays are often almost impervious to water and are chosen for making embankments or dams, but require much longer time in settling from sorghum juice than coarser grained clays. The best clays for settling juice seem to be the brown, yellow, or gray varieties, neither too fine nor too coarse grained, and when sand is present larger quantities should be added to the juice. Many clays consist of a mixture of fine and of coarser grained clays. The coarser particles setttle first and the finer particles last, the juice being cloudy longer than when clay is used which contains only the

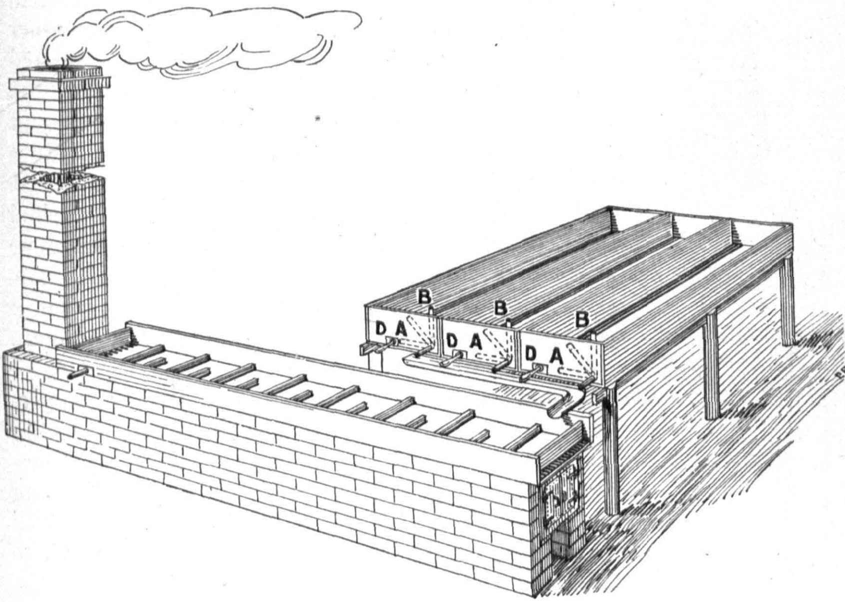

Fig. 6.—Settling tanks for cold clarification.

coarser grains. Some clays are of grains of uniform size and such settle clearly, the line between the clear juice and the settling clay being clearly defined. With such clay the liquid at the surface can be drawn off while the juice a short distance below the surface is still settling; for the settling is complete so far as it has progressed. Ten pounds of dry clay, free from sand, is usually sufficient for 50 gallons of juice, though more may be used. It is well to moisten the clay a few days before using, so as to soften hard lumps, and also to mix or work the clay to the consistence of thin mortar in a box similar to that used in making lime mortar. It is then distributed very quickly and evenly in the juice. After adding the clay the juice should be stirred until the foam becomes white. Then the juice should be left

to settle. When cold, raw juice is treated with clay, three settling tanks are needed; one tank being filled with juice from the mill and one tank used for settling, while the drawing off of the clear juice goes on in the third. Fig. 6 represents an arrangement of settling tanks, A A A for cold settling. When lime is used, about a pint of milk of lime of the consistence of whitewash is put in one of the settling tanks, which is filled, or partly filled with juice, for each 50 gallons of juice contained in the tank and well mixed with the juice. The thin clay mortar is then added and is also well mixed with the juice, stirring until the foam becomes white. The juice is then left to settle, and the same process is used for the second and for the third tank as soon as each contains enough juice. When settled, a swing pipe B is turned partly down so that its upper end is below the surface of the mixture. The settled juice near the surface is then drawn off, leaving the turbid liquid and sediment. If desired, the sediment may be emptied through the washout plug D into a tub beneath the settling tank, where it may be re-settled. The settling tank should then be washed well in order to avoid fermentation, and it would also be well to rinse the cleaned tank with clear lime water. After turning up again the swing pipe B and replacing the washout plug D the tank is again ready to be filled.

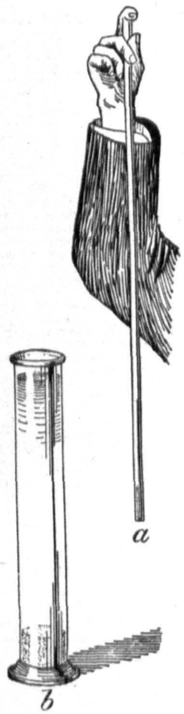

FIG. 7.—*a*. Glass tube used to show how far the juice has settled. *b*. Glass bottle used for same purpose.

It is often difficult to see how far settling has progressed in the tanks so as to know how far the swing pipe can be turned down without drawing off unsettled juice. A glass tube, 12 to 18 inches long, having not more than a quarter of an inch bore, held in a vertical position and inserted cautiously, so as not to disturb the juice until it reaches the bottom of the settling tank, the upper end of the tube being then closed with the finger, on being withdrawn from the liquid gives a section of the juice as it is in the settling tank and shows how much clear juice may be drawn from the top, as illustrated in fig. 7, *a*. Or a tall bottle of clear glass may be filled with clayed juice as soon as the clayed juice is left to settle. The settling will go on in the bottle the same as in the tank, and will show the proportion of settled juice in the tank, as in fig. 7, *b*.

Except in quite cool weather, it is not well to let juice stand over night or to leave the tanks uncleaned at night. It is well to give the juice plenty of time to settle—sometimes one hour is enough; sometimes more is required. The kind of clay, the density of the juice, and the temperature influence the time required for settling.

There are some persons who prefer hot clarification of clayed juice. The process is the same as in cold clarification, except that the juice is first heated to near the boiling point, the blanket of scum is removed, and the hot liquid is then clayed and settled as before, as shown in fig. 8. The clearing of hot clayed juice takes less time than that of cold. The writer prefers cold clarification, and, still better, both the cold and the hot clearing, claying the juice twice, the juice being clayed and cleared cold, as shown in fig. 6, then heated, clayed, and cleared again, hot, as shown in fig. 8. As both clearings go on at the same time but little more time is required than for either cold or hot clearing

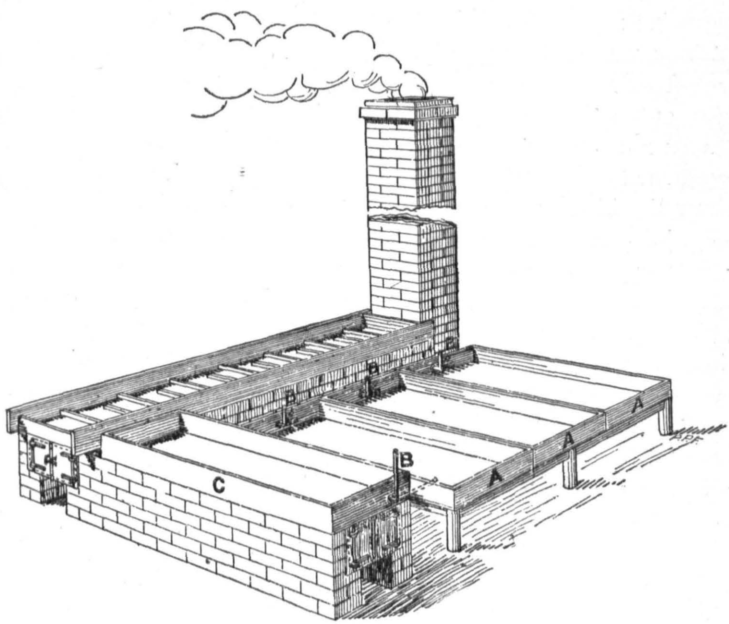

FIG. 8.—Settling tanks for hot clarification.

alone. The sirup from juice which was settled cold, also hot, having been clayed twice, is better than that obtained from one settling, and very much better than that obtained from juice which was merely boiled and skimmed without settling.

SETTLING TANKS.

Shallow settling tanks seem best. The juice settles sooner and more closely to the bottom than in deep tanks. They are cheaper, and also easier to clean. Galvanized sheet iron usually comes in sheets 8 feet long and about 30 to 36 inches wide. By making a box the exact size of the sheet iron, from boards 14 or 16 inches wide, and nailing the sheet iron on for the bottom, a cheap and serviceable settling tank is had, holding 150 gallons or more of juice. In nailing the sheet-iron

bottom on, it is better to drive the nails far apart at first, then divide and subdivide the spaces by nailing, and not to begin nailing at one point and nail closely around. The reason for this is that each nail stretches the iron a little, and when the stretch of the iron is all at one place a bag, or bad place, is found at the finish of the nailing. The washout opening D, fig. 6, for cleaning the tank, is about 2 inches square, tapering a little from the outside, being a little smaller on the inside, with a well-fitted plug. The swing pipe B, fig. 6, is a contrivance for drawing the liquid from the surface. It consists of a piece of $1\frac{1}{4}$-inch pipe about as long as the settling tank is deep, a $1\frac{1}{4}$-inch "elbow," and a "nipple," or short piece of $1\frac{1}{4}$-inch pipe. When connected together these three pieces form a right-angled pipe, the short arm passing through one end of the settling tank as closely as may be to the bottom. The longer arm is free to turn in the elbow, and, when upright, extends above the surface of the juice in the tank, so that the juice does not escape through the pipe. When the longer arm of the pipe is turned down until its upper end is open to the juice at the surface the clear liquid may be drawn off without disturbing that below. By turning the long arm of the pipe D down level with the bottom of the tank A nearly all the juice flows out. It may be drawn off with this much better and more closely to the sediment, without disturbance, than can be done by pouring or dipping out the settled juice.

It is better to have the swing pipe and the washout plug on one end of the tank. It is well to have the opposite end of the settling tank an inch higher than the end which contains the swing pipe and the washout plug, so that the settled juice may nearly all be drawn off down to the sediment, care being taken not to draw it off farther than it has settled. It is not best to make one end of the settling tank so much higher than the other that the sediment will flow or glide to the lower end when drawing off the juice. The sediment should remain where it settled on the bottom, the clear juice draining from it to the the swing pipe.

It would be well for those who wish to test the cold settling or the hot settling, or both settlings of clayed juice, to try the methods in water or in cane juice in a small way. Or, preferably, to dilute a pint of inferior sirup by adding 5 pints of water, claying, settling, and pouring off the settled liquid and evaporating it to sirup, and compare it with the original sirup. In this manner may be noted the differences in clays in settling quickly, closely, and well, and also the improved clearness of the sirup.

EVAPORATING.

There is perhaps no better evaporating pan for small sirup factories than the old "Cook pan," in which the juice enters the pan at the fire end and passes continuously back and forth, in channels, across the pan to the finishing end. The ledges of this pan serve to keep the bot-

tom nearly level, which is an advantage, for it enables the operator to evaporate a thin sheet of juice instead of a larger quantity. If it were possible to evaporate a film of juice one-fourth of an inch deep without burning, it would produce better sirup than would be made in a pan evaporating a sheet of juice 3 inches deep. The evaporation of films of liquid is now becoming common, even where the evaporation is done in a partial vacuum, at low temperatures. When the juice has been well clarified much less skimming is required during the evaporation, and good sirup can be made in a plain pan which can be removed from the heat as soon as the evaporation has been completed.

SUPERHEATING SORGHUM JUICE.

This method of clarifying seems to promise much for sorghum-sirup makers. It is based upon the theory that a higher heat than that which is now used in clarifying juice, coagulates more of the impurities of the juice; that is, it gives a better clarification. In open pans the temperature can be raised no higher than the boiling point of the liquid, for heat passes off in steam, but in closed vessels under pressure, the steam is retained, and the juice may thus be heated to any desired degree. When juice is heated, some of the impurities rise to the surface when the temperature reaches 150° F., more rise at 180°, and still more rise when the temperature reaches 212°. It is said that when sugar-cane juice is heated under pressure, that is, when it is superheated to 240° F., which is about the temperature of finished sirup when boiling in open pans, it is clarified better, gives no scum, settles more readily, and filters better than juice which has been heated to 212° F. only. It is said that the juice of sugar cane from new, rich, moist land is often impure and difficult to clarify, resembling sorghum juice; and that such juice is better clarified by heating it under pressure to a still higher temperature, as much as 270° F. It is also said that this process is now successfully used in Mexico in small factories which work 50 tons of cane in a day, and also in sugar factories in Louisiana which work 1,200 tons of cane a day. It is further stated that 44 sugar factories in this and in other countries are now using this new method of clarifying sugar-cane juice. High heat accomplishes some things which low heat fails to do, and this method, superheating the juice, may give better clarification of sorghum juice. It should be well tested, in an experimental way, in sorghum-sirup manufacture.

SUMMARY.

The subjects discussed in the foregoing pages may be briefly summarized as follows:

Sorghum is more extensively grown in this country than any other sirup producing plant.

Its juice can be made to produce sirup of as good quality as sugar-cane sirup, or molasses.

The manufacture of sorghum sirup has declined throughout the country because the quality of the product is such that other sirups are preferred by the general public, since it ranks in the Northern markets with the middle grades of Louisiana centrifugal molasses.

By improving the quality of sorghum sirup the demand may be increased, its value raised, and its manufacture extended.

Improvement in the quality of sorghum sirup may be made by selecting varieties of sorghum which are best adapted to sirup manufacture, and also by clarifying sorghum juice in more efficient ways.

Improved methods of clárifying sorghum are needed in all sections where sorghum is grown, but are specially needed in the semiarid sections of the West.

The planting and cultivation of sorghum should be such as to allow full development of the canes.

In grinding cane unnecessary loss of juice may often be avoided by the proper adjustment of the mill.

The quality of sorghum sirup is determined by the more or less

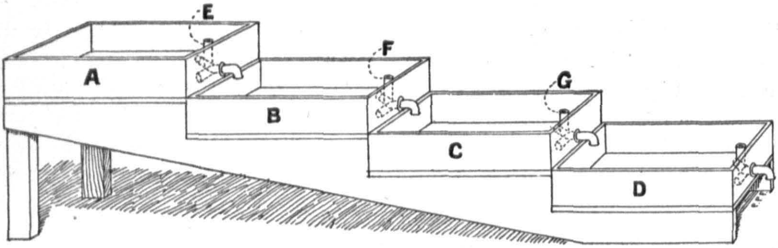

FIG. 9.—Tanks for cold and hot settling.

perfect separation from the juice of the impurities which are solid and of those which are in solution.

The methods recommended are cold settling of raw clayed juice, with or without lime, or settling the heated juice with clay, and with or without lime. The method preferred is to settle cold, limed and clayed juice, draw off and heat the settled juice, clay and settle it, and again draw it off, then evaporate it. These processes are clearly shown in fig. 9, the raw juice being limed, clayed, and settled cold in settling tank A, the settled juice being drawn off by the swing pipe E into the juice heater B, where it is heated to near the boiling point and skimmed; then drawn off by the swing pipe F into the hot settling tank C, where it is again clayed and settled, and the clear juice drawn off by a swing pipe G into the evaporator or receiving tank D. The clarified juice is then evaporated to sirup. By this method most of the solid impurities which were in suspension in the juice are removed.

In fig. 9 the tanks A, B, C, and D illustrate simply the principle of transferring the juice by gravity. In practice the tanks B, C, and D are separated from A and are supplied with a source of heat, either steam or open fire.

Evaporating the juice is best done as shallow as possible without

burning. It should be done quickly, and the sirup should be cooled as soon as possible. With well-clarified juice good sirup can be made in a plain pan, which may be removed from the fire when the sirup is finished.

Sirup, or rather semisirup, so made can be further clarified by an additional process which refines the semisirup by removing impurities in solution, so that it is equal to the best cane sirup.

The additional processes of clarification require further practical experimental work to adapt them to the use of those who manufacture sorghum sirup on a small scale. It is believed that a process for removing the impurities in solution in the juice, after the solid impurities have been removed, may be developed, and that the process may be adapted to those who manufacture sirup on a small scale, so that they may produce a finished and first-class table sirup free from sorghum flavor.

LETTERS FROM REPRESENTATIVE SIRUP MAKERS.

Mr. Seth H. Kenny, of Minnesota, a sorghum-sirup maker of forty years' experience, states:

I have grown the Minnesota Early Amber eighteen successive seasons. We make 10,000 to 15,000 gallons of sirup yearly. We grow cane, and also buy 1,000 to 1,200 tons yearly, at $2 per ton. Last season the average number of gallons of sirup made each day of ten hours was 415. In a previous season we made 15,650 gallons from 94 acres. The average cost of growing cane and hauling it half a mile to the mill was 10 cents per gallon of sirup manufactured. The average cost of making the sirup was 9 cents a gallon. Two pounds of seed are required for an acre. The plants should be thinned. It is important to cultivate cane well when small. When the seed heads begin to turn brown I begin to grind. I cut cane twenty-four to forty-eight hours ahead of my wants. I know nothing better than lime for defecation and the Porter steam pan for evaporation. The lime is about as thick as whitewash when used. About 1 quart of this milk of lime is used in each 100 gallons of juice. A good sirup can be made without lime—and probably nineteen-twentieths is manufactured in this way—but the use of a quart of milk of lime in 100 gallons of juice is preferable. The use of lime at the right time, in the right place, and in the right quantity requires skill. It is necessary to bring the juice nearly to a boil; skim, draw off into the evaporator, boil rapidly, and cool the sirup quickly. The latter should weigh 11½ to 12 pounds per gallon. The pan should be well cleaned once a day. The tanks, etc., should be clean and sweet.

Abstract from the letter of Mr. C. M. Schwarz, of Illinois, a sirup maker of forty years' experience:

I visited a sirup mill last fall. I found the same operations as forty years ago, and sirup of the same appearance, but not so good in quality. Canes from the size of a pencil to that of one's thumb, some green, some ripe, were used.

The stores take the sirup in exchange, and do the best they can with it. Think what the beet would now be if it had been treated as sorghum has in the past forty years.

My most successful method of manufacture was to pass sulphur fumes into the cold juice a short time in the defecators, then hurry the boiling. The work done by the Department of Agriculture in improving varieties of sorghum produced wonderful results, as I found by planting the improved varieties. I used the Cook evaporator twenty years. There are no better evaporators, but a heater or defecator should

also be used; and let the evaporator be made of copper. The sirup maker can obtain sheet copper and make his own pan. The use of copper saves trouble in cleaning; it saves fuel, and besides, a bright pan produces a better sirup. The use of clay has been well spoken of. It never was a success with me. It requires many tanks. The best way to settle cold juice is in a long trough leading from the mill, so arranged as to hold back floating matter and sediment. It should be washed out twice a day. All settling devices which require time are bad; fermentation sets in and the sirup is ropy.

Densmore Brothers, of Minnesota, who have experimented much, state in their letter:

Good defecation is important; evaporation affords no remedy for poor defecation. As it comes from the mill the juice is full of impurities; whatever of these remain in the sirup affect its quality. Many substances have been tried in the defecation but the invariable conclusion is a return to lime. It neutralizes the acids and cuts the gummy matter. It is a necessity to remove impurities from the juice before evaporation begins. In defecating, the juice should be heated to near boiling, then the heat should be shut off and the impurities be allowed to separate as gum and sediment. Three defecators should be used; one being filled, one settling, one being drawn from. An automatic swing pipe drains the juice from near the surface to the evaporator, where there is a valve for regulating the supply. When not in use the swing pipes are turned up to full height, so as not to act. The outlets from the defecators all connect with a pipe which conveys juice to the evaporator. Sorghum sirup is far behind the times, and it will not be satisfactory until sirup makers use up-to-date methods.

Mr. J. P. Wherry, of Missouri, writes as follows:

The first time I tried clay was in a bucketful of juice without lime. It settled nicely, and I used clay for some time before I began the use of lime. It is best to procure a supply of clay before the grinding season. We have a yellow clay with gray streaks, free from sand, about 3 feet below the surface.

In hot weather cane should be ground in the morning and the juice be converted into sirup before closing the factory at night. In cool weather the juice may stand over night. The settling tanks should be clean and not sour from previous use. I never had juice or sirup ropy. It is best to slack half a bushel of lime in a barrel, fill with water, and use the clear lime water to rinse the tanks, after washing them clean. Add half a pint of milk of lime and a quarter of a bushel of clay to each fifty gallons of juice, stir and mix well. Some lots of juice require more stirring than others.

Mr. W. A. Norton, of Iowa, makes the following statements in his letter:

I have a two-horse mill, double sweep, with horse on each end, with an equalizer. In the factory I have three settling tanks with wooden sides and iron bottoms, 8 feet long, 3 feet wide, and 1 foot deep, set up off the ground, so that the juice runs from them to the evaporator, with back end of the tank raised 2 inches, and the outlet about 2 inches above the bottom. I use no lime nor swing pipe, only an outlet pipe. I mix clay thoroughly with the juice and let it settle one hour. I use two pans, 7 feet and 9 feet long, on same arch. The juice is strained through straw and wire at the mill, and the sirup is strained as it comes from the pan. I can purify juice with clay so that not more than one pailful of scum will rise on both pans in a whole day's run. Clay is a success in sorghum sirup manufacture and does away with the impurities that do not rise. My mill started grinding in the morning, and by the time the juice was settled I had cut enough cane with a McCormick corn harvester to run for the day. The only trouble was some of my sirup sugared. I have made sirup over thirty years and have made 3,000 gallons in one season.

Mr. Jacob George, of Iowa, writes:

I have held my trade with the same wholesale dealer for ten years. Cane should not be planted until the weeds have started well before plowing. Fine the soil well, plant in drills 4 to 6 inches between canes and 3 feet 4 inches between rows. Cultivate as soon as the rows can be followed, then give one good hoeing to clear the row. After this cultivate two or three times with "eagle-claw" shovels.

At first, when the cane is very green, strip the leaves when beginning grinding. I use the Folger steam pan, but no lime, clay, chemicals, nor anything except cane juice. I carry the juice 3 to 4 inches deep in the defecator and 1 to 1½ inches in the finisher. Defecating in vats 3 to 4 feet deep is enough to ruin juice. The less juice and the quicker it is finished the better. I do not filter through straw, but have the juice flow in a wide trough a distance of 40 feet or more, which allows much sediment to settle before the juice reaches the defecator. The raw juice should be started to boil slowly, then increase the boiling and finish with a violent boiling, using not less than 80 pounds of steam, and preferably 100 pounds. The capacity of my factory is 10 barrels a day and I shall double it the coming season. I charge 10 cents a gallon to manufacture sirup when the cane is delivered and find it profitable. About every cane mill here has been in operation, and next season will see more cane planted than ever before.

A sirup and molasses dealer, who has long handled quantities of sorghum sirup, makes the following statements:

Our experience has been wholly in the line of selling, not of refining sirups. Our idea for a standard sirup is that it should weigh 11½ pounds to the gallon; if heavier it is liable to sugar; if lighter, to ferment. It should be bright in color, with as mild flavor as possible. Any method that will soften the rank flavor and brighten the color of sorghum will materially improve it. We think you are working in the right direction.

Another firm of jobbbers in sirup and molasses writes:

Sorghum has improved very little since it came into prominence. The fact worth mentioning is that your State (Kansas) produces sorghum which has an objectionable flavor. The best suggestion we can offer is, make the sirup as light as possible in color, of good body, and guard against the objectionable flavor.

FARMERS' BULLETINS.

These bulletins are sent free of charge to any address upon application to the Secretary of Agriculture, Washington, D. C. Only the following are available for distribution:

No. 15. Some Destructive Potato Diseases: What They Are and How to Prevent Them. Pp. 8.
No. 16. Leguminous Plants for Green Manuring and for Feeding. Pp. 24.
No. 18. Forage Plants for the South. Pp. 30.
No. 19. Important Insecticides: Directions for Their Preparation and Use. Pp. 20.
No. 21. Barnyard Manure. Pp. 32.
No. 22. Feeding Farm Animals. Pp. 32.
No. 23. Foods: Nutritive Value and Cost. Pp. 32.
No. 24. Hog Cholera and Swine Plague. Pp. 16.
No. 25. Peanuts: Culture and Uses. Pp. 24.
No. 26. Sweet Potatoes: Culture and Uses. Pp. 30.
No. 27. Flax for Seed and Fiber. Pp. 16.
No. 28. Weeds; and How to Kill Them. Pp. 30.
No. 29. Souring of Milk, and Other Changes in Milk Products. Pp. 23.
No. 30. Grape Diseases on the Pacific Coast. Pp. 16.
No. 31. Alfalfa, or Lucern. Pp. 23.
No. 32. Silos and Silage. Pp. 31.
No. 33. Peach Growing for Market. Pp. 24.
No. 34. Meats: Composition and Cooking. Pp. 29.
No. 35. Potato Culture. Pp. 23.
No. 36. Cotton Seed and Its Products. Pp. 16.
No. 37. Kafir Corn: Characteristics, Culture, and Uses. Pp. 12.
No. 38. Spraying for Fruit Diseases. Pp. 12.
No. 39. Onion Culture. Pp. 31.
No. 40. Farm Drainage. Pp. 24.
No. 41. Fowls: Care and Feeding. Pp. 24.
No. 42. Facts About Milk. Pp. 29.
No. 43. Sewage Disposal on the Farm. Pp. 22.
No. 44. Commercial Fertilizers. Pp. 24.
No. 45. Some Insects Injurious to Stored Grain. Pp. 32.
No. 46. Irrigation in Humid Climates. Pp. 27.
No. 47. Insects Affecting the Cotton Plant. Pp. 32.
No. 48. The Manuring of Cotton. Pp. 16.
No. 49. Sheep Feeding. Pp. 24.
No. 50. Sorghum as a Forage Crop. Pp. 24.
No. 51. Standard Varieties of Chickens. Pp. 48.
No. 52. The Sugar Beet. Pp. 48.
No. 53. How to Grow Mushrooms. Pp. 20.
No. 54. Some Common Birds in Their Relation to Agriculture. Pp. 40.
No. 55. The Dairy Herd: Its Formation and Management. Pp. 24.
No. 56. Experiment Station Work—I. Pp. 30.
No. 57. Butter Making on the Farm. Pp. 15.
No. 58. The Soy Bean as a Forage Crop. Pp. 24.
No. 59. Bee Keeping. Pp. 32.
No. 60. Methods of Curing Tobacco. Pp. 16.
No. 61. Asparagus Culture. Pp. 40.
No. 62. Marketing Farm Produce. Pp. 28.
No. 63. Care of Milk on the Farm. Pp. 40.
No. 64. Ducks and Geese. Pp. 48.
No. 65. Experiment Station Work—II. Pp. 32.
No. 66. Meadows and Pastures. Pp. 24.
No. 67. Forestry for Farmers. Pp. 48.
No. 68. The Black Rot of the Cabbage. Pp. 22.
No. 69. Experiment Station Work—III. Pp. 32.
No. 70. The Principal Insect Enemies of the Grape. Pp. 24.
No. 71. Some Essentials of Beef Production. Pp. 24.
No. 72. Cattle Ranges of the Southwest. Pp. 32.
No. 73. Experiment Station Work—IV. Pp. 32.
No. 74. Milk as Food. Pp. 39.
No. 75. The Grain Smuts. Pp. 20.
No. 76. Tomato Growing. Pp. 30.
No. 77. The Liming of Soils. Pp. 19.
No. 78. Experiment Station Work—V. Pp. 32.
No. 79. Experiment Station Work—VI. Pp. 28.
No. 80. The Peach Twig-borer—an Important Enemy of Stone Fruits. Pp. 16.
No. 81. Corn Culture in the South. Pp. 24.
No. 82. The Culture of Tobacco. Pp. 23.
No. 83. Tobacco Soils. Pp. 23.
No. 84. Experiment Station Work—VII. Pp. 32.
No. 85. Fish as Food. Pp. 30.
No. 86. Thirty Poisonous Plants. Pp. 32.
No. 87. Experiment Station Work—VIII. Pp. 32.
No. 88. Alkali Lands. Pp. 23.
No. 89. Cowpeas. Pp. 16.